TRENDS IN PEDIATRIC ADJUSTED SHOCK INDEX PREDICT MORBIDITY AND MORTALITY IN CHILDREN WITH SEVERE BLUNT INJURIES

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ABSTRACT:

PURPOSE: The utility of measuring the pediatric adjusted shock index (SIPA) at admission for predicting severity of blunt injury in pediatric patients has been previously reported. However, the utility of following SIPA after admission is not well described.

METHODS: The trauma registry from a level-one pediatric trauma center was queried from January 1, 2010 to December 31, 2015. Patients were included if they were between 4-16 years old at the time of admission, sustained a blunt injury with an Injury Severity Score $\geq$15, and were admitted less than 12 hours after their injury (n=286). Each patient's SIPA was then calculated at 0, 12, 24, 36, and 48 hours (h) after admission and then categorized as elevated or normal at each time frame based upon previously reported values. Trends in outcome variables as a function of time from admission for patients with an abnormal SIPA to normalize as well as patients with a normal admission SIPA to abnormal were analyzed.

RESULTS: In patients with a normal SIPA at arrival, 18.4% of patients who developed an elevated SIPA at 12h after admission died, whereas 2.4% of patients who maintained a normal SIPA throughout the first 48h of admission died ($p<0.01$). Among patients with an elevated SIPA at arrival, increased length of time to normalize SIPA correlated with increased length of stay (LOS) and intensive care unit (ICU) LOS. Similarly, elevation of SIPA after arrival in patients with a normal initial SIPA correlated to increased LOS and ICU LOS.

CONCLUSIONS: Patients with a normal SIPA at time of arrival who then have an elevated SIPA in the first 24h of admission are at increased risk for morbidity and mortality compared to those whose SIPA remains normal throughout the first 48h of admission. Similarly, time to normalize an elevated admission SIPA appears to directly correlate with LOS, ICU LOS, and other markers of morbidity across a mixed blunt trauma population. Whether trending SIPA early in the hospital course serves only as a marker for injury severity or if it has utility as a resuscitation metric has not yet been determined.

KEYWORDS: Pediatric, SIPA, Shock Index, Trauma, Injury

INTRODUCTION

The shock index (SI), defined as heart rate (HR: beats per minute) divided by systolic blood pressure (SBP: in mmHg) was initially described by Allgower and Buri in 1967 [1]. Within the adult population a normal SI ranges from 0.5-0.7 and a SI $\geq$0.9 has been considered a "break point" for increased severity of illness [2-4]. The use of SI has been studied the most within the adult trauma population. Elevation of SI at the time of arrival in the emergency department (ED) following polytrauma has been shown to predict need for massive transfusion, intensive care admission, and mortality [4-6]. Additionally, a persistently elevated SI, either pre-hospital to ED or ED to admission, has been shown to predict mortality [2, 3, 5].

However, application of SI within the pediatric trauma population is difficult secondary to differences in HR and SBP in children as a function of age. Recently Acker et al. have defined pediatric-adjusted SI (SIPA) values for children based upon vital signs across accepted age ranges and validated this model as a predictor for injury severity in blunt trauma [7]. Cutoff values for SIPA are as follows: 1.22 (ages 4-6 years), 1.0 (ages 7-12), and 0.9 (ages 13-16) with values above these cutoffs considered abnormal. Since publication of this study, additional work has shown that SIPA has utility in identification of severe head injury, identification of severe isolated blunt liver/spleen injury, need for trauma team activation, and need for abdominal CT after blunt trauma injury [8-12].

While validity for SIPA as an initial marker for injury severity has been established, the utility of following SIPA after admission has not been determined. The purpose of this study was to determine if following trends in SIPA for the first 48 hours (h) in pediatric patients with severe blunt injuries correlated with morbidity and mortality.

METHODS

In order to evaluate trending SIPA in a population where it has been validated, the inclusion/exclusion criteria created by Acker et al. were utilized [7]. The trauma registry from a single institution (Riley Hospital for Children at IU Health, Indianapolis, Indiana) was queried for all

patients sustaining blunt injuries with an injury severity score (ISS) of ≥15 from January 1, 2010 to December 31, 2015. Children were excluded from the study cohort if they were less than 4 years old or greater than 16 years old. Additionally, patients were excluded if they presented to our institution more than 12h after injury. SIPA values were calculated for each patient at the time of arrival and every 12h thereafter until 48h after admission. These scores were then categorized as either "elevated" (i.e. above normal SIPA score for age range) or normal. Additionally, outcome variables related to SIPA previously reported by Acker et al. were reviewed along with demographic data (table 1) [7]. Measured outcome variables included: Intensive Care Unit (ICU) length of stay (LOS), total hospital LOS, days on mechanical ventilation, discharge to rehabilitation, blood transfusion within the first 24h of admission, and in-hospital mortality. Patients were then categorized into two groups based upon their SIPA score at admission (i.e. elevated or not elevated). Trends for outcomes for both groups at each subsequent 12-hour time interval based upon the presence or absence of an elevated SIPA were compiled. Chi-squared analysis and Kruskal-Wallis tests were performed when appropriate with a p-value <0.05 considered statistically significant.

Because the aggressiveness of resuscitation as well as ongoing bleeding after initial evaluation may contribute to alterations in SIPA over the study period, several common variables were analyzed. The amount of packed red blood cells transfused (in mL/kg) and amount of intravenous crystalloid/colloid ("IVF"; in mL/kg) administered were calculated for the first 12h after admission, the second 12h after admission, and the first 24 hours of admission for all patients with available data over this period. In a similar manner urine output (UOP; in mL/kg/h) for the first and second 12h after admission were also calculated and reported as either less than or equal to/greater than 1mL/kg/h . Hematocrit levels (in percentage) were also recorded. These variables were then analyzed against trends in SIPA in a similar manner as previously discussed. Other common variables such as serum lactate and base deficit were not drawn routinely enough for adequate statistical analysis in this study population.

RESULTS

During the study period, 286 patients were identified that met inclusion/exclusion criteria. Demographics and outcome variables for each age range were evaluated and there were no statistically significant differences between age groups (table 1). Among these patients, 79 (27.6%) had an elevated SIPA at the time of arrival (table 1). Additionally, among those children with a normal SIPA at arrival, 57 (19.9%) developed an elevated SIPA at 12h and/or 24h after admission. Trends in outcome variables previously mentioned for patients with elevated SIPA at arrival or those that developed an elevated SIPA after admission were evaluated. P-values given include analyzed time points that were not included in the tables for simplicity.

In-Hospital Mortality

Among patients with an elevated SIPA at the time of arrival, 19% of patients who normalized their SIPA within 12 hours died, whereas 31% of those that normalized in 13-24 hours of admission died and 29% of those who normalized between 25-36 hours of admission died (table 2; p-value=0.152 for Fisher's Exact Test; p-value=0.047 for Likelihood Ratio Chi-Square Test). If a patient's SIPA score was normal at arrival and remained normal throughout the first 48h of admission, 2.4% of these patients died. In contrast, if a patient had a normal SIPA score at admission that was elevated at 12 hours, the mortality rate was 18.4% (table 2). Finally, if a patient had a normal SIPA at admission that was elevated at 24-hours or later (n=45), none of these patients died (p-value<0.01 for overall trend).

Intensive Care Unit Length of Stay (ICU LOS) and Overall Hospital Length of Stay (LOS)

For patients with an elevated initial SIPA, there was an increased ICU LOS for patients as the time to normalize SIPA increased beyond 12 hours (table 3; p-value=0.032). Similarly, those patients who have a normal SIPA at arrival had longer ICU LOS if their SIPA elevated within the first 36 hours of admission (p-value<0.001). Similar trends were seen in overall hospital length of stay (table 3).

Total days of mechanical ventilation

In patients with an initial elevated SIPA, there was a positive correlation between total mechanical ventilation time and time to normalize SIPA (table 3; p-value=0.020). In patients who presented with a normal SIPA, there was no significant difference in the days on the ventilator between those who later had an elevated SIPA and those that did not.

Received blood transfusion within 24 hours of admission

For patients with an elevated SIPA at arrival 29.7% of those that normalized their SIPA within 12 hours of admission received a blood transfusion within 24 hours of admission, where 62.5% of those that required 13-24 hours to normalize their SIPA received blood (table 2; p-value 0.082). For patients with a normal SIPA at arrival, 36.8% of those that had an elevated SIPA at 12 hours of admission underwent blood transfusion. 21.0% of patients with an elevated SIPA at 24 hours after admission and 11.3% of those patients with a normal SIPA throughout the first 48 hours of injury required blood transfusion, respectively (table 2; p-value=0.010).

Discharge to In-patient Rehabilitation

For patients with an elevated SIPA at arrival 13.5% of those that normalized their SIPA within 12 hours of admission required in-patient rehabilitation. For those who required 13-24 hours to normalize their SIPA, 31.2% required in-patient rehabilitation (table 2; p-value=0.152). For patients with a normal SIPA at arrival, 21.0% of those that had an elevated SIPA at 12 hours of admission required rehabilitation. 15.8% of patients with an elevated SIPA at 24 hours after admission and 8.9% of those patients with a normal SIPA throughout the first 48 hours of injury required rehabilitation, respectively (table 2; p-value<0.001)

Injury Severity Score (ISS) and Head Abbreviated Injury Score (Head AIS)

Within both subgroups analyzed, there were no statistically significant differences in ISS or Head AIS for patients as a function of trends in SIPA.

Resuscitation Metrics and Serial Hemoglobin Levels

In patients presenting with an elevated SIPA, there were no differences in total intravenous crystalloid/colloid (IVF) given, or transfused blood during the first 12h, second 12h, or first 24h after admission as a function of time to normalize their SIPA (tables 4&5). Similarly, there were no differences in percentage of patients with UOP $\geq$1mL/kg/h as a function of time to normalize SIPA and serial hematocrit levels (tables 6&7).

In patients presenting with a normal SIPA, there were significant differences in patients with elevated SIPA at 12h and 24h with respect to IVF administered at all time ranges analyzed and total blood transfused within the first 24h (tables 8&9). There were no differences in percentage of patients with UOP $\geq$1mL/kg/h and serial hematocrit levels (tables 10&11).

DISCUSSION

SIPA is a useful tool in the initial assessment and triage of pediatric patients suffering from severe blunt injury. To our knowledge, this study is the first to examine the utility of following the trends in SIPA after initial assessment with regard to important outcome metrics in the pediatric trauma population. Trending a modified shock index within pediatric sepsis patients has yet to prove useful [13, 14]. Yasaka et al. examined utilizing a modified shock index for pediatric patients with septic shock using a different set of age ranges and cutoff values [14]. Within their study group, with the primary outcome measure of ICU mortality, there was no clear cutoff value that was predictive for mortality. The authors state that their data, as well as several studies within the adult trauma population, suggest that persistent elevations in the shock index may represent areas of increased risk for mortality/need for aggressive resuscitation [3, 4, 14]. The pediatric trauma population is unique in as much that the initial insult (i.e. the traumatic injury) is well defined temporally whereas determining the “initial time” for a septic patient is not always clear. Additionally, the utility of the

specific cutoff values for SIPA have be determined based upon previously accepted ranges for vital signs at different age and verified in multiple studies [7-12, 15, 16].

Within this preliminary study, two groups of patients were analyzed; those that had an elevated SIPA upon arrival and those that did not but possibly developed an elevated SIPA within 48h of admission. This study cohort was created based upon inclusion/exclusion criteria previously used to create/verify SIPA within blunt pediatric trauma patients. The trends in SIPA either normalizing from an initial abnormal value or becoming abnormal when initially normal were analyzed.

Among patients with an elevated/abnormal SIPA at arrival, the time to normalize SIPA had direct relation to ICU LOS, total LOS, and total days of mechanical ventilation. It is important to note that reducing time to normalize an initially elevated SIPA did not ultimately show statistical significance for in-hospital mortality. However, other statistical models did reach significance. This inconsistency may be clarified with a larger study population. However, the current data suggests that decreased time to normalize SIPA correlates with several factors for morbidity.

Among patients with an initially normal SIPA, patients who went on to develop an abnormal SIPA, particularly in the first 12h of admission, had significantly worse outcomes. These patients had greater in-hospital mortality, need for early blood transfusion, need for in-patient rehabilitation, ICU LOS, total LOS, and total days on mechanical ventilation. Thus, it appears that the progression from a normal SIPA to an abnormal SIPA is an important early warning sign for worse outcomes and may be a useful target in assessing patients' clinical response to therapy. After review of the study cohort, alterations in SIPA did not necessarily appear to correlate with ongoing bleeding after initial intervention/surgery as these events occurred in less than 5% of the study population, which prohibitied further statistical analysis. Similarly, isolated traumatic brain/spine injuries and possible spinal shock occurred in less than 10% and 2% of the study cohort, respectively.

In order to determine if alterations in SIPA during the first 48h of admission were a function of level of resuscitation or ongoing bleeding, serial IVF, blood transfused, UOP, and hematocrit

levels were analyzed. When analyzing the cohort with an elevated SIPA, there does not appear to be a difference in these metrics as a function of time to normalize SIPA, suggesting that either under resuscitation/ongoing bleeding did not occur frequently, its rate was homogenous across the study subsets, and/or the chosen metrics were not adequate. Indeed, several commonly used resuscitation metrics (i.e. serum lactate levels and serum base deficit) were not obtained frequently enough to complete analysis and serves as a limitation to this study.

In patients with a normal SIPA at arrival, elevations in SIPA at 12h and 24h were associated with higher levels of IVF and transfusions, but no difference in rates of normal range UOP or hematocrit levels. Interestingly, these subgroups were not associated with increased operative intervention for ongoing bleeding based upon individual patient chart review. The nature of these elevations of SIPA after arrival are not completely understood at this time, but could represent a subgroup of patients requiring additional resuscitation, a marker for increased injury severity not appreciated by ISS or initial SIPA score.

Our study is not without limitation. Due to the retrospective nature of this study, only correlations between trends in shock index and the measured outcome variables, resuscitation metrics, and serial hematocrit levels can be made. Additionally, several common resuscitation metrics were not available for analysis within this retrospective study. Ideally, the goal of trending SIPA would be to determine if intervention(s) that correct/keep SIPA within normal limits improve morbidity and mortality. At this time, current data suggests that following SIPA beyond hospital admission serves as an additional marker for injury and helps with prognostication early in the hospital course. Current ongoing research includes evaluating blunt trauma patients with lower ISS for trends in SIPA scores and outcomes.

In a similar manner, sample size across the study period prohibited further in-depth analysis of SIPA within the specific age ranges. Ideally, a larger study would allow analysis within the three age ranges to further determine if the magnitude of elevation in SIPA (or the rate in which it changes) correlate with outcomes, resuscitation metrics, and indices of ongoing bleeding. A study of

this magnitude would likely require multi-institutional collaboration, and should be the next step in determining if there is additional value in following SIPA after admission beyond prognosis.

CONCLUSION

Patients with a normal SIPA at time of arrival who then have an elevated SIPA in the first 24h of admission are at increased risk for morbidity and mortality and had increased resuscitation metrics compared to those whose SIPA remains normal throughout the first 48h of admission. Similarly, time to normalize an elevated admission SIPA appears to directly correlate with LOS, ICU LOS, and other markers of morbidity across a mixed blunt trauma population. Whether trending SIPA early in the hospital course serves only as a marker for injury severity or if it has utility as a resuscitation metric has not yet been determined.

REFERENCES

1. Allgower, M. and C. Burri, *["Shock index"].* Dtsch Med Wochenschr, 1967. **92**(43): p. 1947-50.
2. Oestern, H.J., et al., *Cardiorespiratory and metabolic patterns in multiple trauma patients.* Resuscitation, 1979. **7**(3-4): p. 169-83.
3. Rady, M.Y., et al., *Shock index: a re-evaluation in acute circulatory failure.* Resuscitation, 1992. **23**(3): p. 227-34.
4. Rady, M.Y., et al., *A comparison of the shock index and conventional vital signs to identify acute, critical illness in the emergency department.* Ann Emerg Med, 1994. **24**(4): p. 685-90.
5. Cannon, C.M., et al., *Utility of the shock index in predicting mortality in traumatically injured patients.* J Trauma, 2009. **67**(6): p. 1426-30.
6. Vandromme, M.J., et al., *Identifying risk for massive transfusion in the relatively normotensive patient: utility of the prehospital shock index.* J Trauma, 2011. **70**(2): p. 384-8; discussion 388-90.
7. Acker, S.N., et al., *Pediatric specific shock index accurately identifies severely injured children.* J Pediatr Surg, 2015. **50**(2): p. 331-4.
8. Acker, S.N., et al., *Shock index, pediatric age-adjusted (SIPA) is more accurate than age-adjusted hypotension for trauma team activation.* Surgery, 2017. **161**(3): p. 803-807.
9. Acker, S.N., et al., *A pediatric specific shock index in combination with GMS identifies children with life threatening or severe traumatic brain injury.* Pediatr Surg Int, 2015. **31**(11): p. 1041-6.
10. Acker, S.N., et al., *When is it safe to forgo abdominal CT in blunt-injured children?* Surgery, 2015. **158**(2): p. 408-12.
11. Arbuthnot, M., L.B. Armstrong, and D.P. Mooney, *Can we safely decrease intensive care unit admissions for children with high grade isolated solid organ injuries? Using the shock index, pediatric age-adjusted and hematocrit to modify APSA admission guidelines.* J Pediatr Surg, 2017.

12. Linnaus, M.E., et al., *Prospective validation of the shock index pediatric-adjusted (SIPA) in blunt liver and spleen trauma: An ATOMAC+ study.* J Pediatr Surg, 2017. **52**(2): p. 340-344.
13. Ray, S., et al., *Shock Index Values and Trends in Pediatric Sepsis: Predictors or Therapeutic Targets? A Retrospective Observational Study.* Shock, 2016. **46**(3): p. 279-86.
14. Yasaka, Y., R.G. Khemani, and B.P. Markovitz, *Is shock index associated with outcome in children with sepsis/septic shock?*.* Pediatr Crit Care Med, 2013. **14**(8): p. e372-9.
15. Bledsoe, P., Shade, et al., *Paramedic Emergency Medicine*. Second ed. 1994: Brady: Prentice Hall Division.
16. Kleigman RM, e.a., *Nelson Textbook of Pediatrics*. 19th ed. 2011, Philadelphia, PA: Saunders.

Table 1. Demographics and Outcomes for Children By Age Group

	Age 4-6 (n= 66)	Age 7-12 (n= 134)	Age 13-16 (n= 86)	p-value
Male, n (%)	41 (62.1%)	85 (63.4%)	63 (73.3%)	0.269
ISS, mean (SEM)	22.5 (0.9)	24.2 (0.8)	23.2 (0.9)	0.388
Head AIS median (IQR)	4 (0-4)	4 (0-4)	3 (0-4)	0.381
Elevated SIPA on Arrival, n (%)	12 (18.2%)	44 (32.8%)	23 (26.7%)	0.091
ICU LOS (days) Median (IQR)	1.5 (0-3)	1 (0-3)	1 (1-4)	0.323
Hospital LOS (days) Median (IQR)	5 (3-8)	4 (2-8)	4.5 (3-10)	0.284
Mechanical Ventilation (days) Median (IQR)	0 (0-1)	0 (0-1)	0 (0-2)	0.558
Discharge to Rehabilitation n, %	11 (16.7%)	24 (17.9%)	16 (18.6%)	0.683
Blood transfusion in first 24 hours of Admission n, %	16 (24.2%)	33 (24.6%)	24 (27.9%)	0.098
Ventilator Associated Pneumonia n, %	5 (7.6%)	8 (6.0%)	9 (10.5%)	0.560
Urinary Tract Infection n, %	2 (3.0%)	4 (3.0%)	5 (5.8%)	0.882
Surgical Site Infection n, %	0 (0%)	3 (2.2%)	2 (2.3%)	0.954
Bacteremia n, %	0 (0%)	6 (4.5%)	4 (4.7%)	0.865
All Infections n, %	7 (10.6%)	15 (11.2%)	16 (18.6%)	0.198
Death prior to discharge n, %	5 (7.6%)	13 (9.7%)	6 (7.0%)	0.504

ISS: Injury Severity Score; SEM: Standard Error of the Mean; IQR: Inter-quartile Range; AIS: Abbreviated Injury Score; LOS: Length of Stay

Table 2. Trends in SIPA for Binomial Outcome Variables

	Elevated SIPA at arrival (n=79)		Normal SIPA at Arrival (n=207)		
	Normalized by 12 hours (n=37)	Normalized within 13-24 hours (n=16)	Always Normal SIPA (n=124)	Elevated SIPA at 12 hours (n=38)	Elevated SIPA at 24 hours (n=19)
Death (n; %)	7 (18.9%)	5 (31.2%)	3 (2.4%)	7 (18.4%)	0 (0%)
Survival to discharge (n; %)	30 (81.1%)	11 (68.8%)	121 (97.6%)	31 (81.6%)	19 (100%)
p-value		0.152			**<0.001**
Transfusion in first 24 hours (n; %)	11 (29.7%)	10 (62.5%)	14 (11.3%)	14 (36.8%)	4 (21.0%)
No transfusion in first 24 hours (n; %)	26 (70.3%)	6 (37.5%)	110 (88.7)	24 (63.2%)	15 (78.0%)
p-value		0.082			**0.010**
Discharge to Rehabilitation (n; %)	5 (13.5%)	5 (31.2%)	11 (8.9%)	8 (21.0%)	3 (15.8%)
Rehabilitation not Needed (n; %)	32 (86.5%)	11 (68.8%)	113 (91.1%)	30 (79.0%)	16 (84.2%)
p-value		0.152			**<0.001**

Table 3. Trends in SIPA for Continuous Outcome Variables

	Elevated SIPA at arrival (n=79)				
	Normalized by 12 hours (n=37)	Normalized by 13-24 hours (n=16)	Normalized by 25-36 hours (n=7)	Normalized by 37-48 hours (n=7)	Normalized after 48 hours (n=12)
ICU LOS (median days, (IQR))	2 (1-3)	2 (1-16)	4 (1-15)	7 (3-43)	10.5 (5-12)
p-value					**0.032**
LOS (median days, (IQR))	5 (1-7)	4.5 (1.5-19.5)	9 (1-21)	5 (3-13)	15 (9-20.5)
p-value					**0.018**
Total days on ventilator (median days, (IQR))	1 (1-2)	2 (1-5)	9 (1-9)	5 (2-32)	6.5 (4.5-9)
p-value					**0.020**

	Normal SIPA at Arrival (n=207)		
	Always Normal SIPA (n=124)	Elevated SIPA at 12 hours (n=38)	Elevated SIPA at 24 hours (n=19)
ICU LOS (median days, (IQR))	2 (1-3)	2.5 (1-8)	3 (2-5)
p-value			**<0.001**
LOS (median days, (IQR))	3 (2-5)	6 (4-12)	6 (4-10)
p-value			**<0.001**
Total days on ventilator (median days, (IQR))	1.5 (1-6)	3 (1-9)	3 (1.5-8)
p-value			0.205

Table 4. Comparison of IVF for Elevated SIPA at Arrival

	IVF in first 12h (mL/kg (median (IQR))	IVF in second 12h (mL/kg (median (IQR))	IVF in first 24h (mL/kg (median (IQR))
Normalized by 12 hours	37.6 (18.6-56.0)	26.7 (23.1-37.8)	74.7 (52.6-88.9)
Normalized by 24 hours	42.9 (33.8-50.0)	22.8 (20.9-51.4)	67.0 (58.2-98.8)
Normalized by 36 hours	81.9 (75.7-93.4)	39.7 (21.3-51.3)	133 (114.7-133.6)
Normalized by 48 hours	36.2 (25.7-51.0)	30.4 (23.6-32.9)	70.3 (57.0-86.8)
Normalized after 48 hours	56.6 (32.3-118.0)	42.7 (33.2-61.4)	11.0 (68.0-200.3)
p-value	0.198	0.487	0.336

Table 5. Comparison of Blood Transfused for Elevated SIPA at Arrival

	Blood in first 12h (mL/kg (median (IQR))	Blood in second 12h (mL/kg (median (IQR))	Blood in first 24h (mL/kg (median (IQR))
Normalized by 12 hours	0 (0)	0 (0)	0 (0)
Normalized by 24 hours	2.6 (0-8.5)	0 (0-7.2)	4.3 (0-17.3)
Normalized by 36 hours	0 (0-5.4)	0 (0-6.1)	11.54 (0-19.0)
Normalized by 48 hours	0 (0-10.6)	0(0)	8.4 (0-10.6)
Normalized after 48 hours	10.4 (0-20.8)	0 (0-1.6)	13.5 (0-26.7)
p-value	0.095	0.083	0.068

Table 6. Comparison of Urine Output (UOP) for Elevated SIPA at Arrival

	UOP first 12h (Percent of patients ≥ 1mL/kg/h)	UOP second 12h (Percent of patients ≥ 1mL/kg/h)
Normalized by 12 hours	50%	57%
Normalized by 24 hours	85%	71%
Normalized by 36 hours	60%	80%
Normalized by 48 hours	80%	43%
Normalized after 48 hours	82%	75%
p-value	0.346	0.743

Table 7. Comparison of Hematocrit (Hct) for Elevated SIPA at Arrival

Elevated at 12h	33.8 (30.5-36.2)	33.0 (26.5-35.1)	30.5 (28.0-32.4)
Elevated at 24h	35.9 (28.0-38.8)	29.7 (26.1-34.0)	31.4 (30.8-36.0)
Elevated at 36h	30.9 (25.2-35.9)	32.0 (29.3-33.1)	29.6 (26.3-31.3)
Elevated at 48h	33.9 (28.9-35.6)	25.0 (22.7-33.7)	28.9 (25.9-29.0)
Always Normal	30.7 (28.8-34.8)	30.8 (30.0-32.5)	29.0 (27.2-32.6)
p-value	0.667	0.877	0.578

Table 8. Comparison of IVF for Normal SIPA at Arrival

	IVF in first 12h (mL/kg (median (IQR))	IVF in second 12h (mL/kg (median (IQR))	IVF in first 24h (mL/kg (median (IQR))
Elevated at 12h	39.5 (23.3-61.3)	28.5 (21.8-40.7)	72.3 (46.3-108.4)
Elevated at 24h	40.2 (25.9-61.0)	27.0 (17.1-32.6)	59.8 (51.4-86.6)
Elevated at 36h	30.6 (15.5-52.7)	26.0 (14.3-33.7)	55.6 (37.2-105.4)
Elevated at 48h	23.8 (16.4-37.2)	26.3 (21.7-29.6)	48.9 (44.2-58.4)
Always Normal	23.9 (16.0-39.2)	22.3 (16.9-29.2)	47.7 (46.6-64.2)
p-value	**0.003**	**0.050**	**0.002**

Table 9. Comparison of Blood Transfused for Normal SIPA at Arrival

	Blood in first 12h (mL/kg (median (IQR))	Blood in second 12h (mL/kg (median (IQR))	Blood in first 24h (mL/kg (median (IQR))
Elevated at 12h	0 (0-2.9)	0 (0)	0 (0-6.9)
Elevated at 24h	0 (0)	0 (0)	0 (0)
Elevated at 36h	0 (0)	0 (0)	0 (0)
Elevated at 48h	0 (0)	0 (0)	0 (0)
Always Normal	0 (0)	0 (0)	0 (0)
p-value	0.057	0.162	**0.011**

Table 10. Comparison of Urine Output (UOP) for Normal SIPA at Arrival

	UOP first 12h (Percent of patients ≥ 1mL/kg/h)	UOP second 12h (Percent patients ≥ 1mL/kg/h)
Elevated at 12h	76%	84%
Elevated at 24h	78%	58%
Elevated at 36h	98%	90%
Elevated at 48h	45%	67%
Always Normal	68%	73%
p-value	0.324	0.289

Table 11. Comparison of Hematocrit (Hct) for Normal SIPA at Arrival

	Hct at arrival (Percent (median (IQR))	Hct 12h after arrival (Percent (median (IQR))	Hct 24h after arrival (Percent (median (IQR))
Elevated at 12h	34.4 (31.4-36.9)	29.6 (27.7-33.5)	27.7 (25.5-30.2)
Elevated at 24h	34.8 (32.0-37.8)	30.0 (25.0-33.2)	28.3 (25.7-30.3)
Elevated at 36h	32.5 (31.1-35.3)	29.9 (29.0-32.5)	28.8 (25.8-32.0)
Elevated at 48h	36.6 (34.8-37.6)	33.8 (31.8-36.0)	29.2 (27.2-31.7)
Always Normal	36.0 (32.9-38.2)	32.1 (29.2-35.8)	30.2 (27.8-32.8)
p-value	0.192	0.104	0.485